Available online at www.sciencedirect.com
ScienceDirect

ELSEVIER

August 2014, 21(4): 83–91
www.sciencedirect.com/science/journal/10058885

The Journal of China Universities of Posts and Telecommunications

http://jcupt.xsw.bupt.cn

Exposing photo manipulation with inconsistent perspective geometry

LI Yan (✉), ZHOU Ya-jian, YUAN Kai-guo, GUO Yu-cui, NIU Xin-xin

Information Security Center, Beijing University of Posts and Telecommunications, Beijing 100876, China

Abstract

Manipulated digital image is got interesting in recent years. Digital images can be manipulated more easily with the aid of powerful image editing software. Forensic techniques for authenticating the integrity of digital images and exposing forgeries are urgently needed. A geometric-based forensic technique which exploits the principle of vanishing points is proposed. By means of edge detection and straight lines extraction, intersection points of the projected parallel lines are computed. The normalized mean value (NMV) and normalized standard deviation (NSD) of the distances between the intersection points are used as evidence for image forensics. The proposed method employs basic rules of linear perspective projection, and makes minimal assumption. The only requirement is that the parallel lines are contained in the image. Unlike other forensic techniques which are based on low-level statistics, this method is less sensitive to image operations that do not alter image content, such as image resampling, color manipulation, and lossy compression. This method is demonstrated with images from York Urban database. It shows that the proposed method has a definite advantage at separating authentic and forged images.

Keywords digital images, forgery detection, image forensics, vanishing points

1 Introduction

Forged images are appearing with growing frequency in tabloid magazines, main stream media outlets, scientific journals, evidence in courtrooms, and so on. With the aid of powerful image editing software such as Adobe Photoshop and some advanced digital cameras, forged images can be created easily by even relatively inexperienced users. Furthermore, the doctored photographs are being generated with growing sophistication. It is even difficult for experts to distinguish authentic images from forgeries relying solely on visual inspection. Therefore, forensic techniques for authenticating the integrity of digital images and exposing forgeries are urgently needed.

With advanced image editing software and proficient skills, forgeries may leave no obvious visual clues, and changes of the images may hardly be found by visual inspection. Nevertheless, some underlying statistical or geometric changes, which are detectable, may be brought into the images. These detectable changes could be exploited by approaches of image forensics. In recent years, papers concerned on this subject [1], the digital image forensics has become a hot research field of image processing.

Digital image forensics is divided into five categories according to the information which is utilized for detecting forged images [1]. Pixel-level correlation is utilized in Refs. [2–3]. Properties of joint photographic experts group (JPEG) lossy compression were exploited in Refs. [4–5]. The methods proposed in Refs. [6–9] exploit artifacts introduced by camera lens, sensors or on-chip post-processing. Physical rules, such as lighting inconsistencies [10–11] can be used as the evidence of tampering of digital images. Geometric-based technique is also an important and efficient approach to authenticate the integrity of digital images [12–13].

Basic rules of reflective geometry and linear perspective projection were employed in Refs. [12–13]. In Ref. [13], vanishing points formed by the projected parallel lines are utilized. Recently, many articles [14–17] discussed how to

Received date: 27-12-2013
Corresponding author: LI Yan, E-mail: liyanphoto@gmail.com
DOI: 10.1016/S1005-8885(14)60320-4

compute vanishing points in images captured by pinhole camera. Some estimation methods were used to compute a single vanishing point from a set of projected parallel lines which may not intersect at a unique point precisely. The principle of vanishing points is also utilized here to authenticate the integrity of digital images. But no estimation methods are used, i.e., there is no need to compute a single vanishing point, it is just the distances between the intersection points of the projected parallel lines that are used as the evidence for digital image forensics. The concepts of NMV and NSD of the distances between intersection points are proposed for the image forensics. This technique requires no other assumptions, other than that parallel lines are contained in the image. No information of the internal parameters of the camera is required. Fig. 1 is an example of this kind of image. The parallel lines formed by the windows of the building can be utilized to authenticate the image, which will be illustrated in detail later. The underlying methodology is derived from basic rules of three-dimensional geometry and linear perspective projection. If this technique is added to the growing body of forensic analyses [1], creating undetectable forgery will become more difficult.

Fig. 1 Image containing parallel lines

The rest of this article is organized as follows. In Sect. 2, camera projection and vanishing point are introduced. In Sect. 3, the proposed method is described in detail, which containing four steps: edge detection, straight line extraction, computing intersection points, and image authentication. In Sect. 4, experimental results are presented to demonstrate the efficiency of the proposed method. Sect. 5 concludes this paper.

2 Vanishing point

As described in Ref. [18], the knowledge of camera projection and vanishing point will be reviewed in this section, which will be utilized in the proposed method to detect image manipulation.

In linear perspective projection, the image of an object that stretches off to infinity has finite extent. For example, the image of an infinite scene line is terminating in a vanishing point. The theory of vanishing point can be expressed both in geometric method and in algebraic method.

Geometrically, the vanishing point of the world line is obtained by intersecting the image plane with a ray through the camera center and parallel to the world line. It is the direction of the world line, but not its position, that determines its vanishing point, as illustrated in Fig. 2. Thus, if the world lines are in the same direction, or namely parallel lines, they will have a common vanishing point, as illustrated in Fig. 3. A cuboid, from perspective view, and two sets of parallel lines on it is shown in Fig. 3(a). The lines which are parallel to each other and converge to vanishing point $\boldsymbol{v}_1$ are the diagonal lines of the cuboid. The lines which are parallel to each other and converge to vanishing point $\boldsymbol{v}_2$ are the edge lines and mid-point connection lines of the top and bottom surface of the cuboid. Fig. 3(b) shows the cuboid and the parallel lines from the top view.

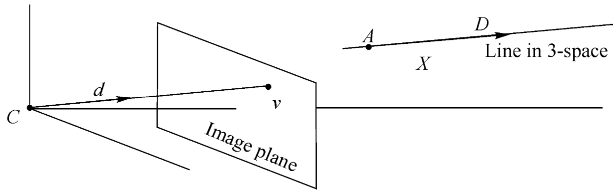
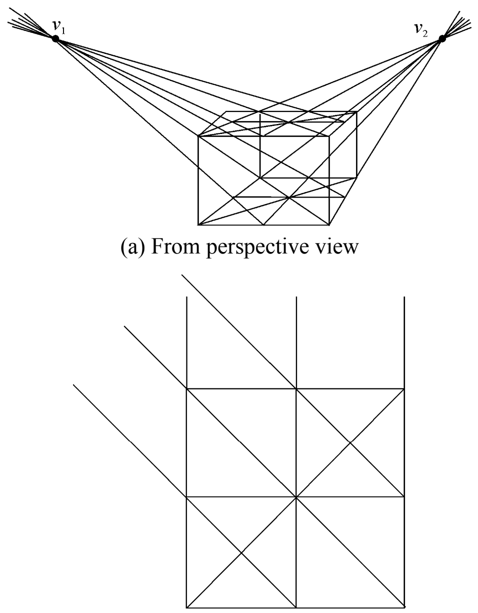


Fig. 2 Way to construct the vanishing point of a line



(a) From perspective view

(b) From the top view

Fig. 3 Vanishing points of two sets of parallel lines on the cuboid